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Research of the Soil Nutrient Measuring System Based on ARM

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Abstract

Nitrogen,phosphorus and potassium are the indispensable nutriments for plants.The appropriate amounts of N、P and K in the soil could be helpful for the growth of crops.It has the vital significance to develop a simple and rapid determination method for Nitrogen,phosphorus and potassium in soil;This design proposes a method of the soil nurtiment measuring system based on ARM,which is based on the spectrophotometric method.LED is chosen as the light source for the soil nutrment measuring system.This paper states weightly the method of the high-precision meaurement from the degree of the circuit theory.

Keywords: ARM； soil nutrenet;spectrophotometric method;LED

1. Introduction

The different crops can be planted in different kinds of soils.But,the crop producers are more concerned about how to determine quickly the kinds and amounts of the fertilizers in accordance with the reasonable expectations production.Rational fertilzation, the maximum yields with the least fertilizers，is based that the varieties and the target yields of plants can determine the kinds and amounts of the

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fertilizers after mearsuring the nutriments in soil .This paper proposes a kind of soil nutriment measuring system based on ARM,which can be used for measuring Nitrogen,phosphorus and potassium in soil.

2. Design of hardware

2.1 The Soil Nutrient Measuring Principle

The soil sample must be made into the tested solution in order to measure the contents of nutriments.Colored solution is relevant with the concentration of solution[1].

Spectrophotometric method is based on Lambert-Beer Law[2].The amount of light penetrating a solution is known as transmittance, expressed as the ratio between the intensity of the transmitted light, I , and the initial light intensity of the light beam, I_0 .Equation (1) is shown:

$$T = \frac{I}{I_0} \tag{1}$$

where: T---Transmittance
I ---Intensity of the transmitted light
I_0 ---Intensity of the initial light beam

And,the light absorption scheme is shown in Fig.1:

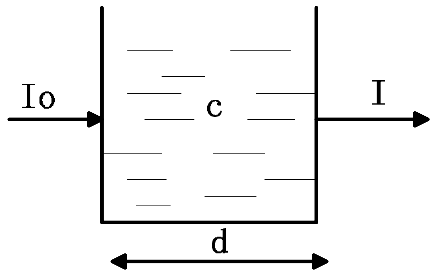

Fig.1. Scheme of the light absorption

Even though the relationship between transmittance and absorbance would appear to be a simple inverse relationship, the true relationship between these two variables is inverse and logarithmic.

$$A = \log(\frac{1}{T}) = -\log T \tag{2}$$

where: A---Absorption
T---Transmittance as a mumber between 0 and 1

The absorption A of a dissolved substance is a linear function of its concentration, the so-called Lambert-Beer Law. The length of the light path (thickness of the cell) and the Extinction coefficient (a substance specific constant) determine the slope of the linear Plot.

$$A = e\,cd \tag{3}$$

where: c—Concentration
d---Thickness of the cell
e *---Extinction coefficient*

The Lambert-Beer Law however is valid only for diluted solutions. The limits for its validity differ for different materials. As a general rule, one can understand that every material showing absorption of up to 0.5 - 0.6 still obeys the Lambert-Beer Law.

Monochromatic light can lessen after through the sample solution,which will be absorpted by the photoelectric receiving diode and be converted to the electrical signal.After then,the electrical signal is imported to ARM.

2.2 The Soil Nutrient Measuring System

The soil nutrient measurement system mainly consistes of input-output system,ARM system, optical system[3],whose hardware structure is shown by Fig.2:

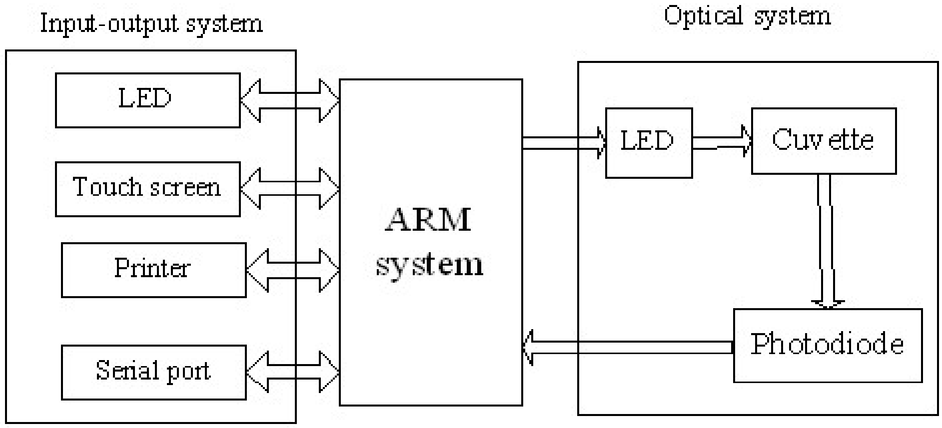

Fig .2. Structure of soil nutrient measurement system

Excepting the mainly parts shown by Fig.2[4],the hardware system else includes the memory module of ARM,the clock circuitry,the reset circuitry.The LCD displaying datas,printing datas,measuring datas,controlling procedures,parameters,chinese character library must be storaged in the memory module[2].In the support of software,the touch screen can operate the soil nutrient measuring system can finish the corresponding measure operations.

This design uses ARM STM32F103ZET as the control chip for the soil nutrient measuring system. STM32F103ZE chip is ARM 32-bit Cortex-M3 microcontroller, 3 12-bit 16-ch A/D Converters. When the ADC clock frequency is 14MHz,the sampling rate of ADC is 1MHz,which can effectively recover the power frequency interference. The ADC has an independent power supply to improve conversion accuracy that can be filtered separately, and shielded from noise on the PCB.

The optical system is actually a cuvette turntable,shown as Fig.2,which includes LED,cuette, photodiode.The cuvette turntable has six sides,can be placed six cuvettes.The characteristics of light source can directly affect the precision of measuring results.In views of current designs with incandescence, visible light, ultraviolet light as light source[5],LED is chosen as Monochromatic light source in this system.The electrical signals tranformed by photodiode[6] will be sent to ADC channel.The red LED is chosen as the light source when measuring N、P,simliarly ,choosing blue LED for K.

The Function CtrlRedLed( ) and CtrlBlueLed( ) can control the red light and blue light through ARM I/O port.The input-output system is consisted of LCD,touch screen,microprinter,serial port[7].The 320*240 LCD can display at most 300 16*16 the Chinese characters,which satisfy the system requirements.The touch screen must cooperate with LCD,which must be calibrated before using.The measuring system can communicate with PC through RS-232[8] ,and the measuring datas can be imported into the upper computer,which also can be printed by microprinter. Construction of references

2.3 Realization of The Nutrient Measuring Function

The measuring process of Nitrogen and phosphorus is similar with the potassium,here Fig.4 is the scheme of measuring N、 P and K:

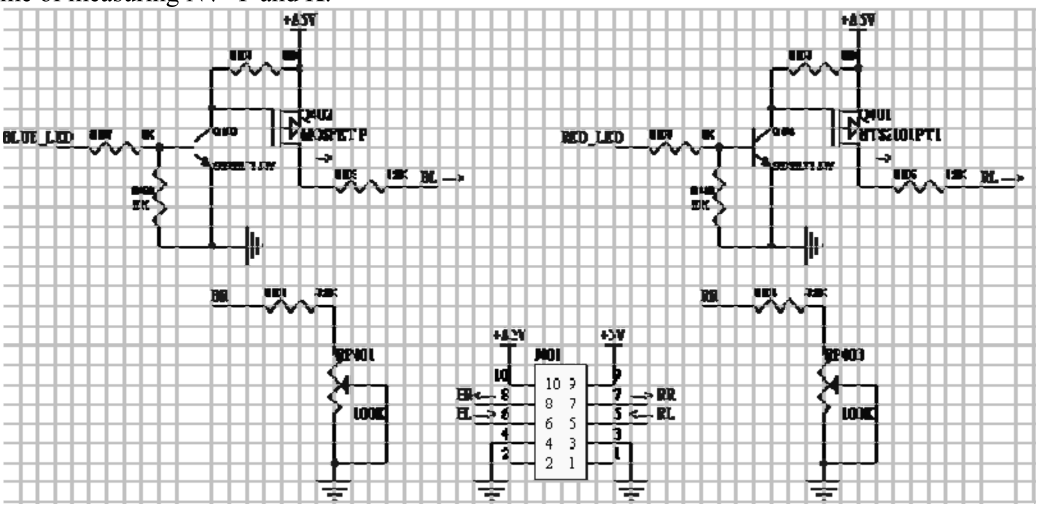

Fig.3. Scheme of measuring N、P、K

Shown by Fig.4,Port J401 is the cuvette turntable,which includes that the red LED is be linked between the RL pin and the ground pin,the photodiode is linked between the +A5V and the RR pin,the RR pin is linked with ARM ADC Channel 12;likewise, the blue LED is be linked between the BL pin and the ground pin,the photodiode is linked between the +A5V and the BR pin,the BR pin is linked with ARM ADC Channel 13.

The red LED is used when meauring N and P,RED_LED is the control signal from ARM.When RED_LED is 0,the power MOSFET Q401 is close,the red LED is not lit.On the contrary,the red LED is lit,the photodiode can conduct due to light.The smaller the solution concentration is ,the less the solution absorbs light,so the more the photodiode receives light,the stronger the current is through R404 and

RP404,the higher the RR pin's electric potential is.Then,the RR's voltage is collected by ARM ADC.The RR's voltage is not important for the nutirent measurement due to the comparison method,but,the voltage must be more than 2.5V.

The photodiode should be not allowed in the saturated state.The reference vlotage of ADC is 2.5V,RP403 should be adjusted in order to measure the different solution concentrations.Here, the electric potential of RR pin should be more than 2.5V when the blank solution is measured.

In this system,LED must be good monochromaticity.Otherwise,the measuring results are not accurate because of LED's different wavelengths.

Shown as Equation(3), Absorption A is linear with Concentration c,when Thickness of the cell d and Extinction coefficient e are constants.Assuming that the voltage V1 of the RR pin is corresponding with the blank solution.,simililarly,V2 is corresponding with the 60ppm standard solution,which can be determined a straight line by (V1,0) and (V2,60).When the unkown solution is corresponding with V3,the solution concentration can be determined from the straight line.

3. Conclusion

This method to design the soil nutrient measuring instrument, characteristics of lower cost,highter stability,can guarantee the reliable measuring results and can satisfy the agriculture needs.

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